

## Greenhouse Modelling

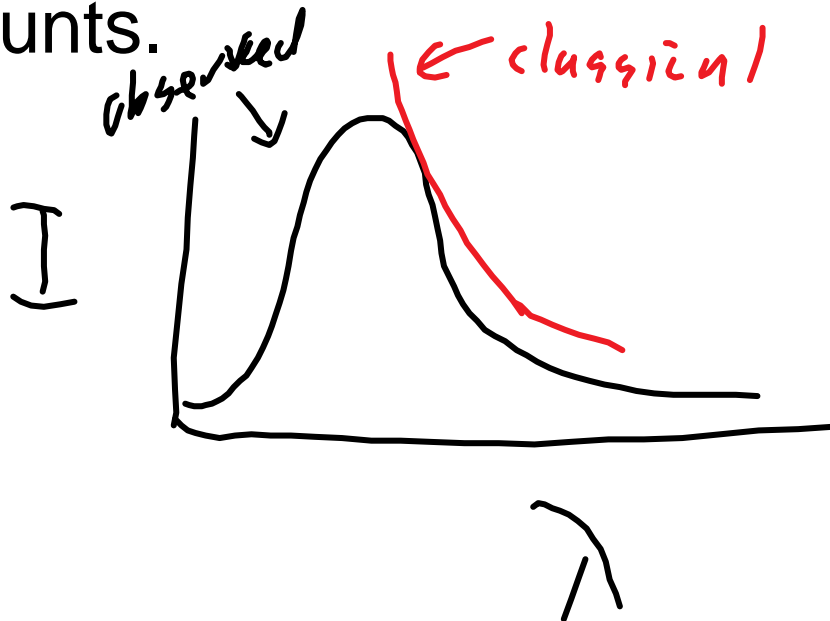
Look at energy input/output models of Earth's temperature and factors that influence.

Model of thermal emission - blackbody radiation - black body emits and absorbs energy at all wavelengths.

recall Planck - German government hired him to build a better lightbulb.

He found the classical model of blackbody electromagnetic emission to

be off the measured values by crazy amounts.



Ultraviolet catastrophe - breakdown of Maxwell's equations to describe blackbody radiation.

Planck - assumed that electromagnetic radiation came in bundles, photons, with energy  $E=hf$ . - math worked

given that, we can predict the electromagnetic emission of a black body by

Integrate the  $I$  graph, the area under it related to the power output,  $P$

$$P = e\sigma AT^4$$

P is the total power output of a body, in W - spreads out in all directions, like a spherical

A is the surface area, in  $m^2$  - usually a sphere  $A = 4\pi r^2$

T is the temperature in Kelvin!!!

$\sigma$  is Stefan-Boltzman constant

$$5.67 \times 10^{-8} \text{ Wm}^{-2}\text{K}^{-4}$$

e is cheat constant - emissivity - how far is the object from a perfect blackbody,

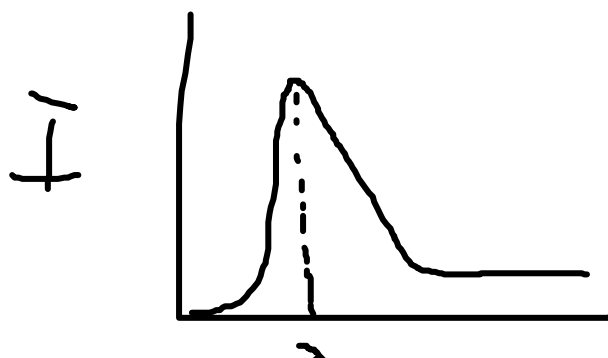
e=1 a perfect non emitting object e=0

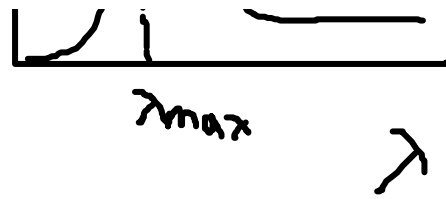
Earth is about 0.5

$$\lambda_{\max} = 2.9 \times 10^{-3} / T \quad \text{data booklet}$$

(m)

$\lambda_{\max}$  is the peak emission wavelength, in m





(should be called peak wavelength)

$2.9 \times 10^{-3}$  should have units of  $m \cdot K$

albedo,  $\alpha$  = power scattered/power in

1. The Sun has a surface temperature of 5000K, Earth has an average temperature of  $15^{\circ}\text{C}$ , and you have a surface(skin) temperature of  $34^{\circ}\text{C}$

Radius of Sun - 695 500km

of Earth  $6.37 \times 10^6 \text{m}$

Radius of you? guestimate

distance between Earth/sun  $1.50 \times 10^{11} \text{m}$

- a) What is the total power output of Sun (treak as perfect blackbody  $e=1$ ), Earth  $e=0.50$  , you  $e=0.98$ ?
- b) peak wavelength for Sun, Earth, you
- c) What is the power input from the sun on the Earth? treat the Earth like a disk  $1.50 \times 10^{11} \text{m}$  from the Sun with the

energy spread over a sphere. What is the Intensity?  $= P/A$

- d) What albedo for the Earth would allow the power input from c to balance the power output of the Earth from a?
- e) given your answer to b) why are greenhouse gasses (carbon dioxide, methane, water...) effective at absorbing heat from the Earth?